Effect of Liquid-Phase Surface Tension on Hydrodynamics of a Three-phase Airlift Reactor with an Enlarged Degassing Zone

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Airlift reactors are especially useful for operations requiring solid-suspension without high shear force (e.g. fermentation and cell culture). Fermentation broths are complex mixture of cells, sugars, electrolytes, proteins, etc. and exhibit high viscosity, low surface tension and non-Newtonian characteristics [1]. However, the majority of hydrodynamic data for airlift reactors has been obtained with air/water systems, with properties different from the real conditions of operation. It is, nevertheless, known that both liquid viscosity and surface tension affect gas holdup. The small bubbles formed in liquids with reduced surface tension may enhance gas holdup.

It is considered that dilute aqueous alcohol solutions simulate reasonably well the liquid-phase behaviour in bioreactors [2], being the surface tension the only physical property which differs significantly from water. Aqueous solutions of ethanol represent a coalescence inhibiting system, which will affect bubble size and the overall hydrodynamics.

The aim of this study is to compare the behaviour of a three-phase airlift reactor (60 l), of the concentric draught-tube type, with an enlarged degassing zone when water and an aqueous solution of ethanol are used as liquid-phase. The concentration of ethanol used (10 g/l) is higher than the limiting concentration (0.11 mol/l) reported by Zahradník *et al.* [3], in order to observe the maximum deviation possible. Ca-alginate beads were used as solid-phase. Gas and solids holdup in the riser and in the downcomer, circulation and mixing times and riser and downcomer interstitial liquid velocity were measured for both liquid-phases, changing solids loading (0% to 30% (v/v) and airflow rate (from 1.9 to 90.2 l/min).

The reduction in surface tension with the addition of ethanol has a great influence on the hydrodynamics of the airlift reactor being observed, as primary consequence, the increase of riser gas holdup and the augment of the entrance of gas into the downcomer. Deriving from the increase of the riser and downcomer gas holdup a decrease of solids holdup in these sections is observed. However, the difference between gas and solids holdup in the riser and in the downcomer remains practically constant when ethanol is added. Consequently, due to the maintenance of the driving force for the circulation, the circulation time for the ethanol solution is similar to the one observed for water. The lower riser and downcomer solids holdup observed for ethanol causes a decrease of the riser and downcomer interstitial liquid velocity. With the exception of the high solids loading and the low airflow rates, the presence of ethanol in the liquid-phase increases the mixing time in the three-phase system.

References

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